High-Performance Fume Hood

High-Performance Technology Developed by the

A-Team

The Applications Team
Lawrence Berkeley National Lab

EXHAUST HOODS—CRITICAL BUT COSTLY

Exhaust hoods protect operators from breathing harmful fumes by capturing, containing, and exhausting hazardous gases created in laboratory experiments or industrial processes. These box-like structures, often mounted at tabletop level, offer users protection with a movable, window-like front "face" called a sash. Fans draw fumes out the tops of the hoods.

Fume hoods typically exhaust large volumes of air at great expense. The energy to filter, move, cool or heat, and in some cases scrub (clean) this air is one of the largest loads in most lab facilities. A six-foot-wide hood typically exhausts 1200 cubic feet per minute (cfm), 24 hours per day, and consumes more energy than an average house.

Figure 1: Standard fume hood in use. Courtesy of Labconco Corp.

STANDARD HOODS

Design Characteristics Dictate High Exhaust Rates

Fume hood exhaust induces airflow through the fume hood's "face." The generally accepted "face velocity" is 100 feet/minute; a high airflow rate causing large exhaust flows. Interestingly, increasing face velocity does not improve containment. Instead, errant eddy currents and vortexes are induced around hood users as air flows into the hood, reducing containment effectiveness.

Fume hoods frequently operate 24 hours/day. Since many laboratories have multiple hoods, they typically dictate a lab's required airflow and thus the supply and exhaust systems' capacity. The result is larger fans, chillers, boilers and ducts compared to systems having less exhaust. Consequently, fume hoods are a major factor in making a typical laboratory four to five times more energy intensive than a typical commercial space.

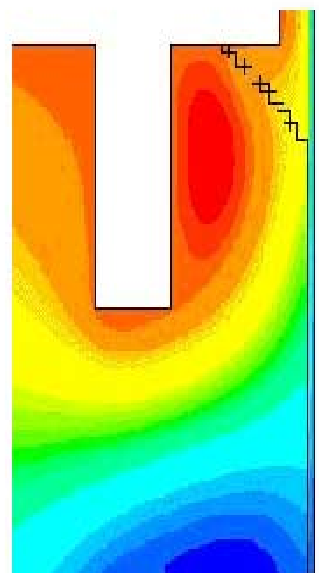

Figure 2: Computer model of airflow through a standard fume hood. Shading indicates air speed, with darker colors being faster. Upper & lower vortexes (dark areas) trap air and tend to spill.

State-Of-The-Art System Limitations

State-of-the-art, energy-efficient fume hoods require several interactive features and diligent users. Sophisticated controls for the hood and in the supply and exhaust air streams communicate with a variable air volume (VAV) system to provide a constant face velocity and a pressure differential between the laboratory and adjacent space. These controls add significantly to the system's first cost and complexity.

Energy savings occur only if the sash is less than fully open and the fan slows to reduce exhaust flow while maintaining a constant face velocity. Each hood user must operate the sash properly to ensure that the system achieves the full energy savings potential. Also, when sizing air distribution and conditioning equipment, many designers assume worst-case conditions—all sashes fully open—requiring larger ducts, fans, and central plants than if assuming some sashes are partly closed.

THE INVENTION

The Berkeley Hood: a High-Performance Fume Hood

Lawrence Berkeley National Laboratory has developed a promising new technology, a High-Performance Fume Hood, referred to as the Berkeley Hood in this document. The Berkeley hood reduces airflow requirements by 50 to 70 percent while maintaining or enhancing worker safety. The flow reduction cuts energy costs about $1,000/year per hood installation in California, with higher savings likely in more extreme climates.

Berkeley Lab's hood design uses a "push-pull" approach to contain fumes and exhaust them from the hood. Small supply fans located at the top and bottom of the hood's sash, or "face," gently push air into the hood (see Figure 3). These low-velocity airflows create an "air divider" that separates the fume hood's interior from the exterior (unlike an air curtain approach that uses high-velocity airflow).

Berkeley Lab's air-divider approach of separating and distributing air leads to greater containment and exhaust efficiency. The result is an extremely effective and energy-efficient unit.

Revolutionary Design Delivers Numerous Benefits

Beyond the 50–70 percent ventilation reduction and associated energy savings, the Berkeley Hood offers design features which deliver a range of benefits, including:

- Simpler design than the state-of-the-art VAV fume hood systems offers easier and less expensive installations.
- Constant volume operation ensures that energy efficiency is not dependent on the operator.
- Clean room-air flowing into the operator's breathing zone reduces potential hazard from fumes.
- Airflow patterns reduce dangerous eddy currents and vortexes, improving containment and exhaust performance.

In new construction projects, designers can easily specify the Berkeley Hood and achieve energy cost savings. The Berkeley Hood is expected to have a cost premium over a current standard hood. However, this cost premium can be offset with savings from smaller ducts, fans, and central plants, as well as simpler control systems, offering lower overall first cost than standard hood systems.

In retrofit projects, Berkeley Hood users will receive critical HVAC system benefits beyond energy savings. Many laboratories are "starved" for air as their need for hoods has grown over the years. In some cases, low supply or exhaust airflows cause inadequate exhaust and potential hood spillage. Since increasing airflow is very costly in most cases, many laboratories cannot add new hoods. By replacing existing hoods with Berkeley Hoods, users can increase the number of hoods or improve exhaust performance.

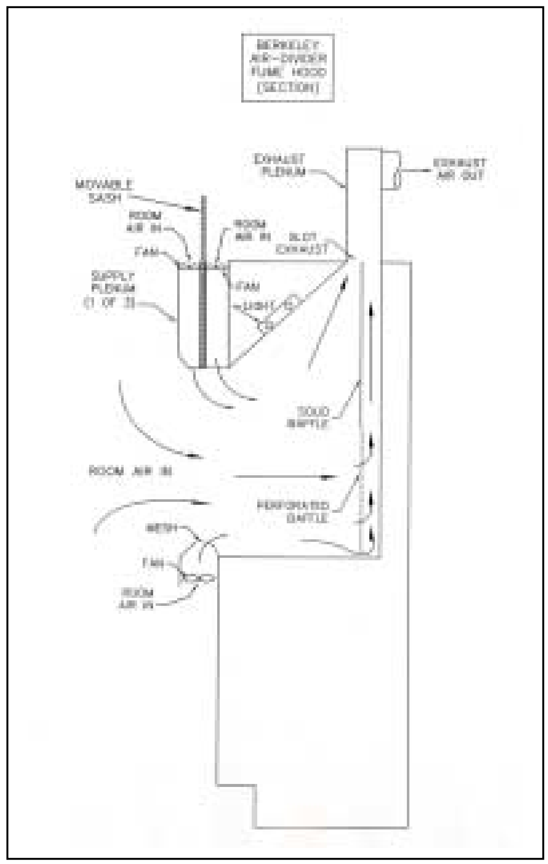

Figure 3: Schematic of the Berkeley Hood; side view shows airflow patterns.

Researchers estimate the new Berkeley Hood could save about 360 million kWh/year in California, totaling nearly $30 million. Nationally, energy savings could total $300 million annually.

BRINGING LABORATORY RESEARCH TO MARKET

Major Achievements

- ✔ Established high-performance containment design concept.
- ✔ Conducted CFD modeling to speed design optimization.
- ✔ Completed schlieren visualization testing to confirm capture and containment.
- ✔ U.S. Patent number 6,089,970 issued for the basic concept; additional patents will be issued for advanced features.
- ✔ Conducted ASHRAE Standard 110-1995 test and achieved containment with 70 percent flow reduction using alpha prototype.
- ✔ Established partnerships with laboratory hood and controls manufacturers to develop and test alpha units.
- ✔ Signed intellectual property agreement for product development in the microelectronics field.
- ✔ Conducting new field tests in 2002 with larger version; started additional field test in 2001; completed two field tests in 2001.

Figure 4: Prototype unit demonstrating the air divider.

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